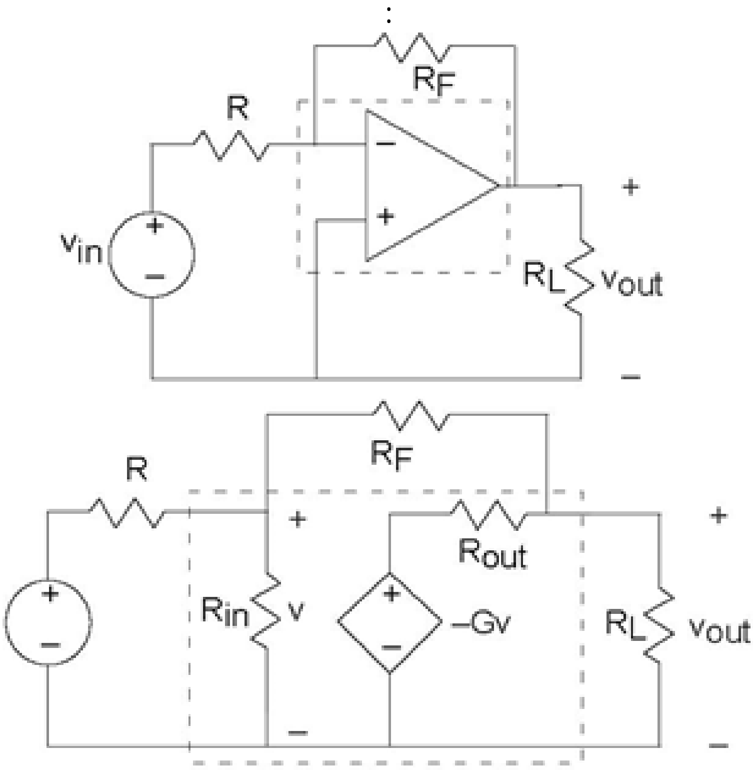

Figure 3.41 feedback op-amp The top circuit depicts an op-amp in a feedback amplifier confguration. On the bottom is the equivalent circuit, and integrates the op-amp circuit model into the circuit.

Note that the op-amp is placed in the circuit "upside-down," with its inverting input at the top and serving as the only input. As we explore op-amps in more detail in the next section, this configuration will appear again and again and its usefulness demonstrated. To determine how the output voltage is related to the input voltage, we apply the node method. Only two node voltages ***v*** and ***v***$_{\text{out}}$ need be defined; the remaining nodes are across sources or serve as the reference. The node equations are

$$\frac{v - v_{in}}{R} + \frac{v}{R_{in}} + \frac{v - v_{out}}{R_F} = 0$$

$$\frac{v_{out} - (-G)v}{R_{out}} + \frac{v_{out} - v}{R_F} + \frac{v_{out}}{R_L} = 0$$

Note that no special considerations were used in applying the node method to this dependent-source circuit. Solving these to learn how ***v***$_{\text{out}}$ relates to v_{in} yields

$$\left(\frac{R_F R_{out}}{R_{out} - G R_F}\left(\frac{1}{R_{out}} + \frac{1}{R_i n} + \frac{1}{R_L}\right)\left(\frac{1}{R} + \frac{1}{R_{in}}\frac{1}{R_F}\right) - \frac{1}{F_F}\right) v_{out} = \frac{1}{R} v_{in}$$

This expression represents the general input-output relation for this circuit, known as the **standard feedback configuration**. Once we learn more about Operational Amplifiers (Page 89), in particular what its typical element values are, the expression will simplify greatly. Do note that the units check, and that the parameter ***G*** of the dependent source is a dimensionless gain.